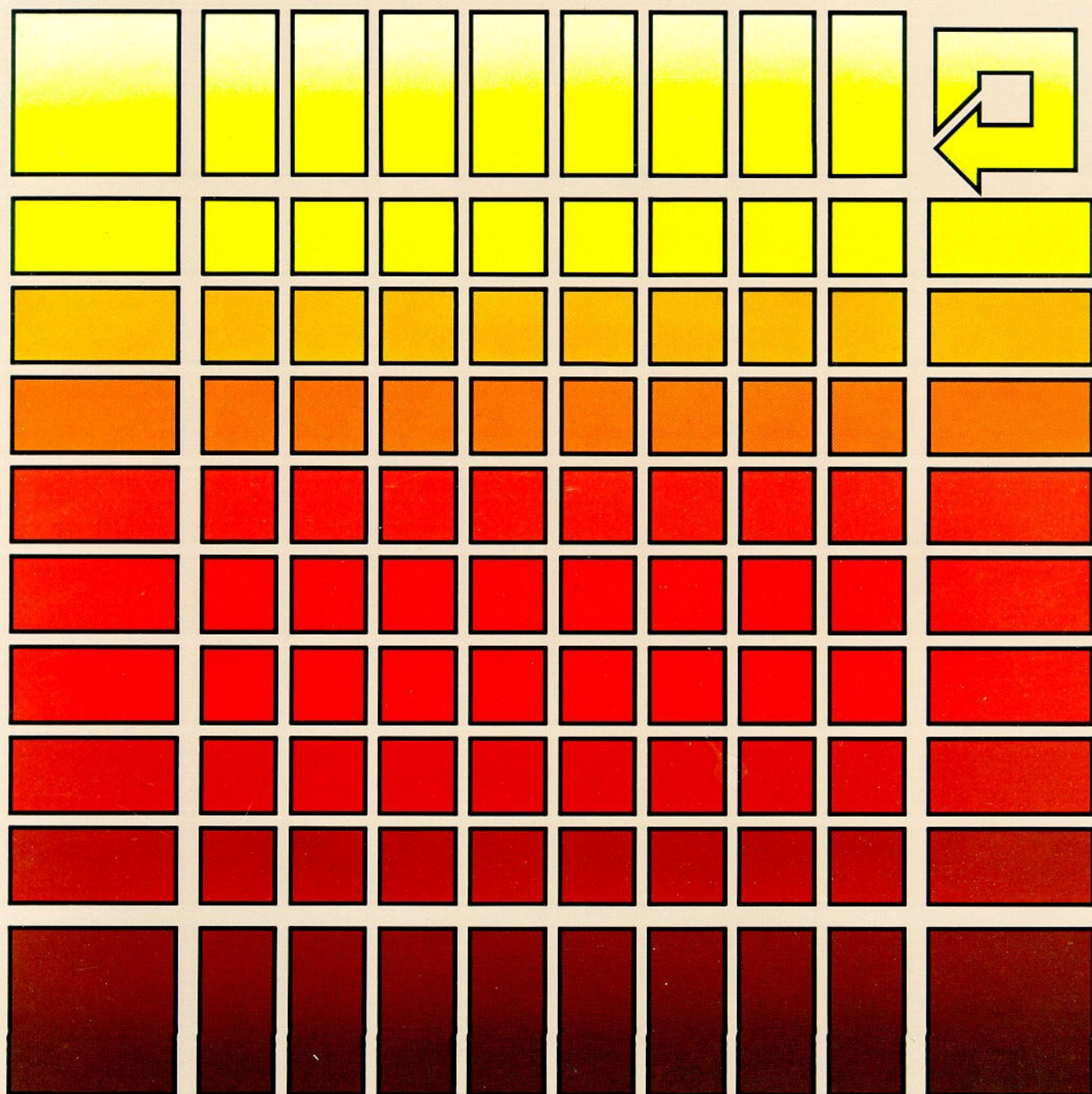


HEWLETT-PACKARD

HP 82165A

HP-IL/GPIO Interface

OWNER'S MANUAL





HP 82165A
HP-IL/GPIO Interface
Owner's Manual

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Introduction

The HP 82165A HP-IL/GPIO Interface provides the capability to interface an external device having general-purpose input/output (GPIO) capabilities with the Hewlett-Packard Interface Loop (HP-IL).

The HP 82165A HP-IL/GPIO Interface is packaged with the following accessories:

- One HP-IL cable.
- A mating 25-pin D-subminiature GPIO connector.
- An ac adapter.

Additional HP-IL cables are available in packages of one:

- ½ meter (1½ feet)—model number HP 82167A.
- 1 meter (3 feet)—model number HP 82167B.
- 5 meter (16 feet)—model number HP 82167D. (This length may not be available in all countries.)

This manual gives information about the interface's design, its interaction with HP-IL, and its operation using the GPIO capabilities of the external device. Operating specifications are included to assist in interfacing the interface and the external device. (Typical installations are described in appendix C.)

Installation

The following paragraphs describe how to set up the HP 82165A HP-IL/GPIO Interface in an HP-IL system.

GPIO Connection

Before plugging the 25-pin D-subminiature GPIO connector into the interface, wire the GPIO connector to the external device and disconnect the power to the interface.

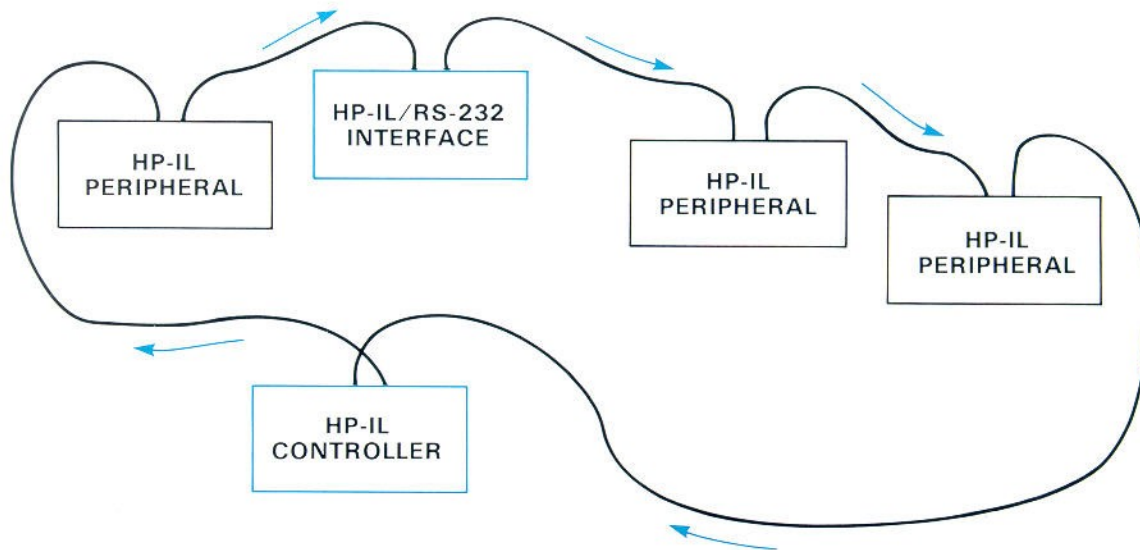
Power

The HP-IL/GPIO interface is powered by an ac adapter. Because the interface does not have a battery, it can operate only when the adapter is connected to the interface and a proper ac outlet. To install the adapter, first make sure that the interface is disconnected from HP-IL. Next, insert the ac adapter plug into the proper ac outlet. Finally, insert the power connector into the power receptacle in the rear of the interface.

HP-IL Connection

The Hewlett-Packard Interface Loop (HP-IL) consists of one or more peripheral devices and a controller (a calculator or computer). The devices may be connected in any order—but all of the interface cables must form a continuous loop. All connections are designed to ensure proper orientation.

To connect the HP 82165A HP-IL/GPIO Interface onto the loop, first turn off the controller. Then disconnect the loop in one place and connect the interface onto the loop at that place. (In some instances, the interface may be the only peripheral in the loop.)



Operation

The HP 82165A HP-IL/GPIO Interface becomes operational when the ac adapter is connected, when it is coupled to a controller via the HP-IL, and when it is properly coupled to an external device through the GPIO bus. You should refer to the owner's manual for your calculator, computer, or HP-IL extension to find the primary information about controlling the interface.

Appendix A contains information about verifying proper operation of the interface.

The keyboard on top of the interface contains a few controls that allow you to set and monitor the interface's operation.

RESET Key. The RESET key is a momentary switch that returns the interface to its initial startup conditions (page 10).

PWR Light. The power (PWR) light is on whenever the ac adapter supplies power to the interface.

T/R Light. The transmit/receive (T/R) light goes on each time data is transferred across the GPIO bus. More technically, the light is on each time the DAVI or DAVO signal is true. The light is lit only for the duration of the transfer, so it will often appear to flash or blink.

MSRQ Key. Pressing the manual service request key (MSRQ) sets a Manual Service Request condition in the status register. (Refer to page 14 for more details.)

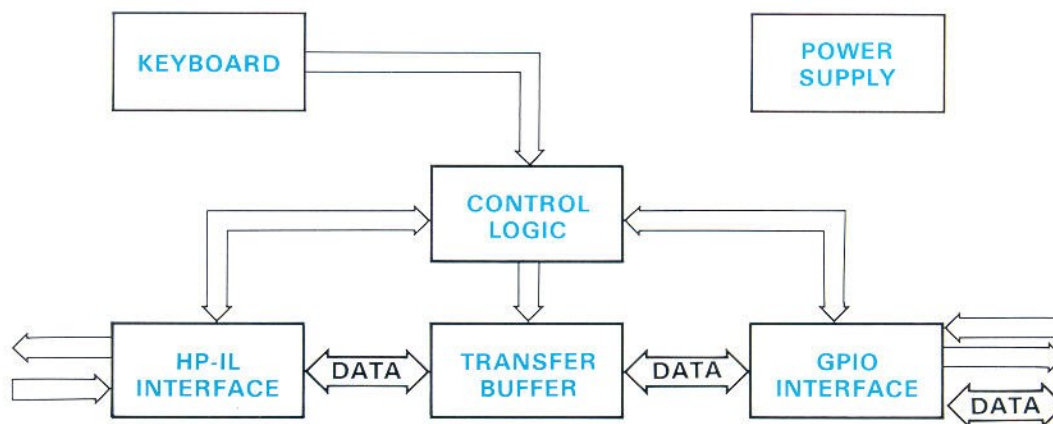
An Overview of the HP-IL/GPIO Interface

Consider the HP-IL system shown below. The interface loop contains an HP-IL *controller* (such as a calculator), perhaps one or more additional HP-IL devices, and the HP-IL/GPIO interface. The interface connects to an *external device* (such as a GPIO printer), allowing the controller to interact indirectly with the external device. In this way, the external device becomes an HP-IL controlled peripheral.

If the controller needs the external device to send data to listeners on HP-IL, the controller first makes the interface a talker, which means that the interface is set to accept data from the external device and send it on HP-IL. The controller then directs the interface to start sending data. The interface uses its three GPIO input “handshake” lines (RDYO, DAVI, and DACO) to control the flow of data on the data lines. The interface sets the RDYO line true. When the external device places one byte on the data lines, it sets DAVI true. The interface sets the DACO line true when it has accepted the data byte and has stored it internally. The interface accepts and stores additional bytes in the same manner. Meanwhile, the interface sends each byte on HP-IL, where it is received by all HP-IL listeners. This is called an HP-IL \leftarrow GPIO (“HP-IL from GPIO”) operation.

Note: Not all controllers can use all of the interface's features. Some controllers may require an I/O (input/output) module (or "ROM") in order to control certain aspects of the interface's operation. (Refer to the appendices for additional information.)

The HP-IL/GPIO interface has six primary features that are important for understanding the interface's operation: the HP-IL interface, the GPIO interface, the transfer buffer, the control logic, the keyboard, and the power supply.



HP-IL Interface

The HP-IL interface portion of the interface performs standard operations required by the interface loop, such as maintaining the interface's talker or listener status, and accepting and passing HP-IL messages around the loop. The physical connection to HP-IL consists of standard HP-IL receptacles—one for incoming messages and one for outgoing messages.

GPIO Interface

The GPIO interface portion of the interface provides the connection to the external device. The physical connection consists of a 25-pin D-subminiature GPIO connector. By making the appropriate connections, the external device and the interface use signal lines to send and receive information. The signal lines include two 8-line GPIO data buses, six GPIO handshake lines, two HP-IL interfacing lines, and a ground line. (Signal descriptions are described on page 9.)

Transfer Buffer

The transfer buffer consists of 32 registers, each capable of holding one byte of information. (Each byte consists of eight bits.) This buffer stores information being transferred from HP-IL to GPIO or from GPIO to HP-IL. It gives the interface the capability of holding up to 32 bytes waiting to be sent. The buffer passes data in the order it was received—first in, first out.

Control Logic

The control logic stores operating information, implements various operating modes that can be selected, and controls the flow and interpretation of data within the interface. It includes registers that store operating information: the control registers and the status register. This operating information can come from either the HP-IL controller or the interface's keyboard.

Control Registers. The operation of the interface is defined by information stored in 19 control registers—R00 through R18. Each register stores one byte (eight bits) of control information. The tables in appendix B list the effects of the control registers. When power is applied to the interface, the default values listed in the appendix are stored in the control registers. The contents of the registers may be changed by subsequent operations on HP-IL. (Refer to the Device Dependent Listener 0 message on page 13.)

Note: In this manual, individual bits in a control register are indicated by appending them to the register name. For example, bits 7 and 6 of control register R02 are indicated by R02-7,6.

Status Register. Information about the current state of the interface is stored in the status register. This register stores one byte of status information, as described on page 13.

Keyboard

The keyboard contains the RESET key, the MSRQ (manual service request) key, the PWR (power) indicator light, and the T/R (transmit/receive) indicator light. The RESET key and the MSRQ key allow you to interact with the interface and set certain states. (The operation of these two keys were explained on page 6.) When the PWR indicator light is lit, there is power to the interface. The T/R light is lit during the transfer of data across the GPIO bus.

Power Supply

The HP-IL/GPIO interface contains no internal power source; therefore, the interface must be connected to the ac adapter. The power supply provides a regulated voltage to the interface.

Signal Descriptions

The HP-IL/GPIO interface provides two interfaces: a pair of standard HP-IL receptacles in the front panel and a 25-pin D-subminiature GPIO connector at the rear of the unit. (Electrical and timing specifications are listed on pages 19 and 20.)

HP-IL Signals

The interface provides full electrical and mechanical compatibility with HP-IL. The interface's two HP-IL receptacles connect to the interface loop using standard HP-IL cables. Because information travels around the loop in one direction, the receptacles are labeled IN and OUT, indicating the direction of communication and the sequence of normal HP-IL addressing.

GPIO Signals

The interface provides two 8-line bidirectional GPIO data buses, six GPIO handshake lines, two HP-IL interfacing lines, and a ground line. These lines are available to the external device at the 25-pin GPIO connector. Each input and output line is TTL-compatible.

Data Bus A (DA0-DA7). These GPIO lines can be configured as an input/output bus or as an input-only bus. Data Bus A transfers information between transfer buffer and the external device.

Data Bus B (DB0-DB7). These GPIO lines can be configured as an input/output bus or as an output-only bus. Data Bus B transfers information between the transfer buffer and the external device.

GPIO Output Handshake Lines (RDYI, DAVO, DACI). These three lines, used in four different combinations, provide four methods of data output to GPIO (HP-IL → GPIO). A true RDYI input indicates that the external device is ready to receive data. A true DAVO output indicates that the data on the data buses is valid; when DAVO is false, the data bus lines are high. A true DACI input indicates that the external device has received the data.

GPIO Input Handshake Lines (RDYO, DAVI, DACO). These three lines control the input of data from GPIO (HP-IL ← GPIO). A true RDYO output indicates that the interface is ready to receive data. A true DAVI input indicates that the data on the data buses is valid. A true DACO output is the only indication that the interface has received the data. (The external device is not required to use the RDYO and DACO output signals.)

HP-IL Interfacing Input Line ($\overline{\text{MSRQ}}$). This input line allows the interface to signal the HP-IL controller. An active low $\overline{\text{MSRQ}}$ signal causes the interface to request service from the HP-IL controller by setting the service request bit in Identify, Data Byte, or End Byte HP-IL messages. It also affects the internal status byte. Manual service requests—those initiated by this signal—can be disabled by setting R00-6 equal to 0.

HP-IL Interfacing Output Line ($\overline{\text{GETO}}$). This output line informs the external device that a Group Execute Trigger message has been received on HP-IL. An active low signal on the $\overline{\text{GETO}}$ line sets a Group Execute Trigger message.

GPIO Signal Descriptions

| Name | Description | Direction |
|--------------------------|------------------------------|------------------------------------|
| DACI | Data Accepted Input | Interface \leftarrow Device |
| DACO | Data Accepted Output | Interface \rightarrow Device |
| DAVI | Data Valid Input | Interface \leftarrow Device |
| DAVO | Data Valid Output | Interface \rightarrow Device |
| DA0 - DA7 | Data Bus A | Interface \leftrightarrow Device |
| DB0 - DB7 | Data Bus B | Interface \leftrightarrow Device |
| $\overline{\text{GETO}}$ | Group Execute Trigger Output | Interface \rightarrow Device |
| GND | Ground | Interface \leftrightarrow Device |
| $\overline{\text{MSRQ}}$ | Manual Service Request | Interface \leftarrow Device |
| RDYI | Ready Input | Interface \leftarrow Device |
| RDYO | Ready Output | Interface \rightarrow Device |

Operation

The HP-IL/GPIO interface's basic function is to transfer data between HP-IL and the external GPIO device. For data transfer from HP-IL to the external device (HP-IL \rightarrow GPIO), the interface must be an HP-IL listener—receiving data on HP-IL and sending it on GPIO. For data transfer from the external device to HP-IL (HP-IL \leftarrow GPIO), the interface must be an HP-IL talker—receiving data on GPIO and sending it on HP-IL. The listener and talker status is determined by the controller.

The interface interacts with devices connected to the interface loop and with the external device. The HP-IL interaction is defined in terms of standard HP-IL messages sent and received by the interface. The GPIO interaction with the external device consists of signals transmitted on the GPIO control and data lines.

Startup Conditions

When the ac adapter applies power to the interface, the interface is initialized according to the default parameters in the control registers. (Refer to appendix B.) The interface's HP-IL address is undefined, preventing the interface from performing any HP-IL operation until it is assigned a valid address by the HP-IL controller.

HP-IL Interaction

The interface provides complete compatibility with HP-IL. It interacts with other HP-IL devices by sending and receiving HP-IL messages on the interface loop. (Refer to the owner's manual for the HP-IL controller for information about controlling peripherals such as the HP-IL/GPIO interface.) The interface responds to HP-IL messages as described in the table below. Except as noted in the table, each HP-IL message the interface receives is automatically sent to the next device in the loop. In general, the interface checks each message it initiates for transmission errors when the message comes back to the interface.

Responses to HP-IL Messages

| HP-IL Message | Interface Response |
|--------------------------------|---|
| COMMAND GROUP | |
| Interface Clear | Talker or listener status removed and pending addressable message cleared. |
| Device Clear | No response. |
| Selected Device Clear | No response. |
| Go To Local | No response. |
| Local Lockout | No response. |
| Remote Enable | No response. |
| Not Remote Enable | No response. |
| Parallel Poll Enable 0-15 | If listener and not already parallel poll enabled, set to modify subsequent Identify messages according to parallel poll conventions. (Refer to pages 14 and 15.) |
| Parallel Poll Disable | If listener, set to not modify subsequent Identify messages. |
| Parallel Poll Unconfigure | Set to not modify subsequent Identify messages. |
| Group Execute Trigger | Pulses GETO line low. |
| Loop Power Down | No response. |
| Enable Asynchronous Requests | No response. |
| Auto Address Unconfigure | Address set to 8. |
| Listen Address 0-31 | If address matches,* data for HP-IL cleared from transfer buffer, device removed from talker status, and device becomes a listener. If address is 31, device removed from listener status. (End-of-line sequence sent to GPIO, if enabled to do so.) |
| Unlisten | Device removed from listener status. (End-of-line sequence sent to GPIO, if enabled to do so.) |
| Device Dependent Listener 0-31 | If listener, responds as described in table on page 13. |
| Talk Address 0-31 | If address matches,* device removed from listener status and becomes a talker. If address doesn't match, device removed from talker status. |
| Untalk | Device removed from talker status. |
| Device Dependent Talker 0-31 | If talker, responds as described in table on page 13. |
| Secondary Address 0-30 | Following addressed message, if primary and secondary addresses match device's addresses, responds to message. |
| Null | No response. |
| READY GROUP | |
| Take Control | If talker, the response is not defined. (Operation as a controller is not supported.) |
| Ready For Command | Executes a pending Loop Power Down message. |
| Send Data | If talker, begins sending contents of transfer buffer or GPIO registers, as selected.† |
| Send Device ID | If talker, sends eight ASCII-coded bytes: HP 82165A.+ |
| Send Accessory ID | If talker, sends one byte with the value 64.+ |
| Not Ready For Data | If talker, makes previous data byte the last byte sent. |
| Send Status | If talker, sends one byte of status. (Refer to pages 13 and 14.)† |

Responses to HP-IL Messages (Continued)

| HP-IL Message | Interface Response |
|---|--|
| End Of Transmission—OK | If talker, responds as described under End of Data, page 18. If listener, end-of-line sequence sent to GPIO if enabled to do so. |
| End Of Transmission—Error | If talker, sent immediately for bad HP-IL error check. If listener, end-of-line sequence sent to GPIO if enabled to do so. |
| Auto Address 0–31 | If device has earlier assigned address, no response. If message address is 31, no response. If message address less than 31 and device doesn't have earlier assigned address, device address set to message address, increments message address by one, and passes revised message. |
| Auto Extended Primary 0–31 | If device has earlier assigned address, no response. If address is 31, no response. If not preceded by Auto Extended Secondary message, no response. If preceded by Auto Extended Secondary 31, no response. If preceded by Auto Extended Secondary less than 31, if message address less than 31, and if device doesn't have earlier assigned address, then device address is set to primary and secondary addresses just received. |
| Auto Extended Secondary 0–31 | If device has earlier assigned address, no response. If address is 31, no response. If message address less than 31 and device doesn't have earlier assigned address, device secondary address set to message address, increments message address by one, and passes revised message. (Must be followed by Auto Extended Primary message to establish valid device address.) |
| Auto Multiple Primary 0–31 | No response. |
| IDENTIFY GROUP | |
| Identify (no service request) | If device set to respond by Parallel Poll Enable message, modifies message according to parallel poll setup and service request status. (Refer to pages 14 and 15.) |
| Identify (service request) | |
| DATA GROUP | |
| Data Byte (no service request) | If talker, sends next data byte. [†] |
| Data Byte (service request) | If listener, accepts data byte and passes to next device. Data is normally sent to transfer buffer. If service is required by interface, message is modified to Data Byte (service request). |
| End Byte (no service request) | If talker, sends next data byte. [†] |
| End Byte (service request) | If listener, accepts data byte and passes to next device. Data is normally sent to transfer buffer. (End-of-line sequence sent to GPIO, if enabled to do so.) If service is required by interface, message is modified to End Byte (service request). |
| * For extended addressing, the message address must match the primary address. The response occurs only if the correct Secondary Address message follows. | |
| [†] Indicates that the received message is not passed to the next device in the loop. | |

Device Dependent Messages. Device Dependent Listener messages and Device Dependent Talker messages (listed in the command group above) are special HP-IL messages whose meanings depend upon the device receiving them—the listener or the talker. When these messages are sent to the interface, they are referred to by names that correspond to the specific actions they cause. Device dependent message numbers, names, and responses are listed below.

Responses to Device Dependent Messages

| HP-IL Message | Name | Interface Response |
|-----------------------------------|------------------------|--|
| Device Dependent Listener: | | |
| 0 | Set Control Registers | Transfer buffer cleared. Up to 19 subsequent Data Bytes from HP-IL are stored in R00 through R18. |
| 1 | Interface/HP-IL Test | Interrupts GPIO output and clears transfer buffer. Subsequent Data Bytes are held in transfer buffer waiting to be sent to HP-IL (not sent to GPIO). Subsequent HP-IL output operation allows comparison with original Data Bytes. (Refer to Verifying Proper Operation in appendix A.) |
| 2 | Clear Transfer Buffer | Transfer buffer cleared. |
| 3-31 | | No response. |
| Device Dependent Talker: | | |
| 0 | Send Control Registers | Subsequent Send Data message causes the contents of R00 through R18 to be sent on HP-IL (19 Data Bytes). Transfer buffer cleared. |
| 1 | Send Data Bus B | Subsequent Send Data message causes one Data Byte representing the data on Data Bus B to be sent to the transfer buffer. (No input handshake is used.) |
| 2 | Enable End-Of-Line | Sets interface for detecting and deleting end-of-line sequence in GPIO input and inserting different end-of-line sequence into HP-IL output (ending with an End Byte). Operates on next string of Data Bytes only. The GPIO end-of-line sequence must be the last Data Bytes in the buffer. Requires that R04-7 and R04-3 equal 1. Sequences specified by R04 through R14. |
| 3-31 | | No response. |

Status. The interface maintains a one-byte record of its current condition in the status register. The definition of the status byte is shown in the table below. Normally, the status condition in the status register is updated whenever the interface's status changes. However, for the Buffer Busy condition, the status register is not changed until an HP-IL Send Status message causes the status to be sent on HP-IL.

Status Byte Definition

| Status Byte | | Condition | Definition |
|-------------|----------|-------------------------|---|
| Decimal | Binary* | | |
| 1 or 65 | 0X000001 | Ready For HP-IL Data | Ready to receive data on HP-IL (HP-IL → GPIO). |
| 2 or 66 | 0X000010 | Data Ready For HP-IL | Data available in transfer buffer for HP-IL (HP-IL ← GPIO). |
| 4 or 68 | 0X000100 | Buffer Full (for GPIO) | Transfer buffer is full (HP-IL → GPIO). |
| 6 or 70 | 0X000110 | Buffer Full (for HP-IL) | Transfer buffer is full (HP-IL ← GPIO). |
| 8 or 72 | 0X001000 | No GPIO Handshake | During HP-IL → GPIO operation, DACI not received within DAVO timeout period or RDYI not received. |
| 16 or 80 | 0X010000 | Buffer Busy | Transfer buffer not empty and data sent from external device during HP-IL → GPIO operation. (Data not accepted by interface.) |
| 32 or 96 | 0X100000 | Manual Service Request | MSRQ line set low by the external device or by pressing the MSRQ key on the interface. |

* The eight bits are shown in order—bit 7 (most-significant) through bit 0 (least-significant). An X indicates that bit 6 may be either a "0" or a "1". If bit 6 is a "1" (corresponding to the higher decimal value), the interface has originated a service request on HP-IL. Bit 6 is reset to a "0" when the status condition changes.

Service Requests. Two types of conditions can cause the interface to initiate a service request (indicated by a control bit in an HP-IL Data Byte, End Byte, or Identify message): a *manual* service request and a *status* service request. A manual service request is initiated by an active low signal from the external device on the MSRQ input line or by pressing the MSRQ key. A status service request is initiated by the occurrence of a particular condition as indicated by the status register. The conditions that cause a service request are specified by control register R00. (If a condition is enabled in register R00, the occurrence of that condition will initiate a service request on HP-IL.)

R00-7 controls whether certain status conditions initiate HP-IL service requests. R00-6 controls whether a manual service request condition initiates an HP-IL service request. If R00-7 is set, either R00-5 can make *all* status conditions initiate service requests, or else R00-4 through R00-0 select *particular* status conditions to initiate service requests.

Parallel Poll. The interface can be enabled to respond to a parallel poll. A parallel poll allows the HP-IL controller to determine which devices require attention. When it receives an HP-IL Parallel Poll Enable message, the interface is set to respond in a particular way to subsequent parallel polls. The parallel poll consists of an HP-IL Identify message sent by the active HP-IL controller. If the interface has been parallel poll enabled, it modifies all Identify messages according to the table below. Basically, for the first eight enable messages listed below, a "no service request" condition makes the designated bit a "1"; otherwise, the bit is not affected. For the last eight enable messages, a "service request" condition makes the designated bit a "1"; otherwise, the bit is not affected. In all cases, a "service request" condition is indicated by placing a "1" in the Service Request bit in the Identify message. No other bits are affected by the interface.

If the interface receives a Parallel Poll Unconfigure message, or if the interface is a listener and receives a Parallel Poll Disable message, the interface won't respond to subsequent parallel polls—that is, it doesn't modify Identify messages.

Parallel Poll Response to Identify Message

| Enable Message | Designated Bit | Effect on Designated Bit | |
|-------------------------|----------------|--------------------------|-------------------------|
| | | If Service Requested | If No Service Requested |
| Parallel Poll Enable 0 | Bit 1 | "0" → "0"* "1" → "1"* | "0" → "1" "1" → "1" |
| Parallel Poll Enable 1 | Bit 2 | | |
| Parallel Poll Enable 2 | Bit 3 | | |
| Parallel Poll Enable 3 | Bit 4 | | |
| Parallel Poll Enable 4 | Bit 5 | | |
| Parallel Poll Enable 5 | Bit 6 | | |
| Parallel Poll Enable 6 | Bit 7 | | |
| Parallel Poll Enable 7 | Bit 8 | | |
| Parallel Poll Enable 8 | Bit 1 | "0" → "1"* "1" → "1"* | "0" → "0" "1" → "1" |
| Parallel Poll Enable 9 | Bit 2 | | |
| Parallel Poll Enable 10 | Bit 3 | | |
| Parallel Poll Enable 11 | Bit 4 | | |
| Parallel Poll Enable 12 | Bit 5 | | |
| Parallel Poll Enable 13 | Bit 6 | | |
| Parallel Poll Enable 14 | Bit 7 | | |
| Parallel Poll Enable 15 | Bit 8 | | |

* Also, Service Request bit is set to "1".

GPIO Interaction

The interface's interaction with the external device (using the GPIO data and control lines) is directly related to the way that the interface is set up to operate. The HP-IL controller determines the contents of the control registers, which define the converter's operation—including its GPIO interaction. The controller uses the Device Dependent Listener 0 message (page 13) to change the control registers, defined in appendix B.

Data Transfer. Normally, the flow of data in the interface is determined by the interface's role in the interface loop. When the interface is an HP-IL listener, data moves from HP-IL to the transfer buffer and then to the external device on the GPIO bus. When the interface is not a listener and the transfer buffer has no data from HP-IL, the external device can send data to the interface. When the interface is an HP-IL talker, data moves from the external device via the GPIO bus to the transfer buffer and then to HP-IL. The GPIO data bus is half-duplex: it can transfer information in only one direction at a time.

Data Bus Configuration. The interface has two eight-line data buses (DA0-DA7 and DB0-DB7) that can be organized in three ways: 8-bit bidirectional, 8-bit input and 8-bit output (unidirectional), and 16-bit bidirectional. These options are specified by control register R02-2,1. For 16-bit bidirectional operation, Data Bus A carries the most-significant bits and Data Bus B carries the least-significant bits. The table below summarizes the data bus options.

Data Bus Options

| Configuration | Selected by* | Options |
|---|--------------|--|
| 8-Bit Bidirectional: Data Bus A external device Data Bus B (not used) | R02-2,1 = 00 | Positive Logic (R02-5 = 0) Negative Logic (R02-5 = 1) |
| 8-Bit Unidirectional: Data Bus A external device Data Bus B external device | R02-2,1 = X1 | |
| 16-Bit Bidirectional: Data Bus A external device Data Bus B external device | R02-2,1 = 10 | |
| * An X indicates that the bit is ignored, so the bit may be either a "0" or a "1". | | |

Handshake. For HP-IL → GPIO operations, the interface provides four GPIO handshake options: full handshake, valid/accepted handshake, ready/valid handshake, and strobed output. For each option, when DAVO is true, the data on the data bus is valid; when DAVO is false, the data lines are high. The handshake options are specified by control register R02-7,6. The following tables summarize the handshake options.

Output (HP-IL → GPIO) Handshake Options

| Handshake | Selected by | Options |
|---|--------------|--|
| Full Handshake: RDYI, DAVO, DACI | R02-7,6 = 11 | Positive Logic (R02-4 = 0) Negative Logic (R02-4 = 1) 100-μs DAVO Time Unit (R02-3 = 0)* 5-μs DAVO Time Unit (R02-3 = 1)* No DAVO Timeout (R02-0 = 0)* DAVO Timeout (R02-0 = 1)* DAVO Pulse Width Number (R03) |
| Valid/Accepted: DAVO, DACI | R02-7,6 = 10 | |
| Ready/Valid: RDYI, DAVO | R02-7,6 = 01 | |
| Strobed: DAVO | R02-7,6 = 00 | |
| * For ready/valid and strobed output, these options aren't used: the DAVO signal time unit is automatically 5 μs, and the DAVO signal always remains true for the number of units specified by R03. | | |

Input (HP-IL ← GPIO) Handshake Options

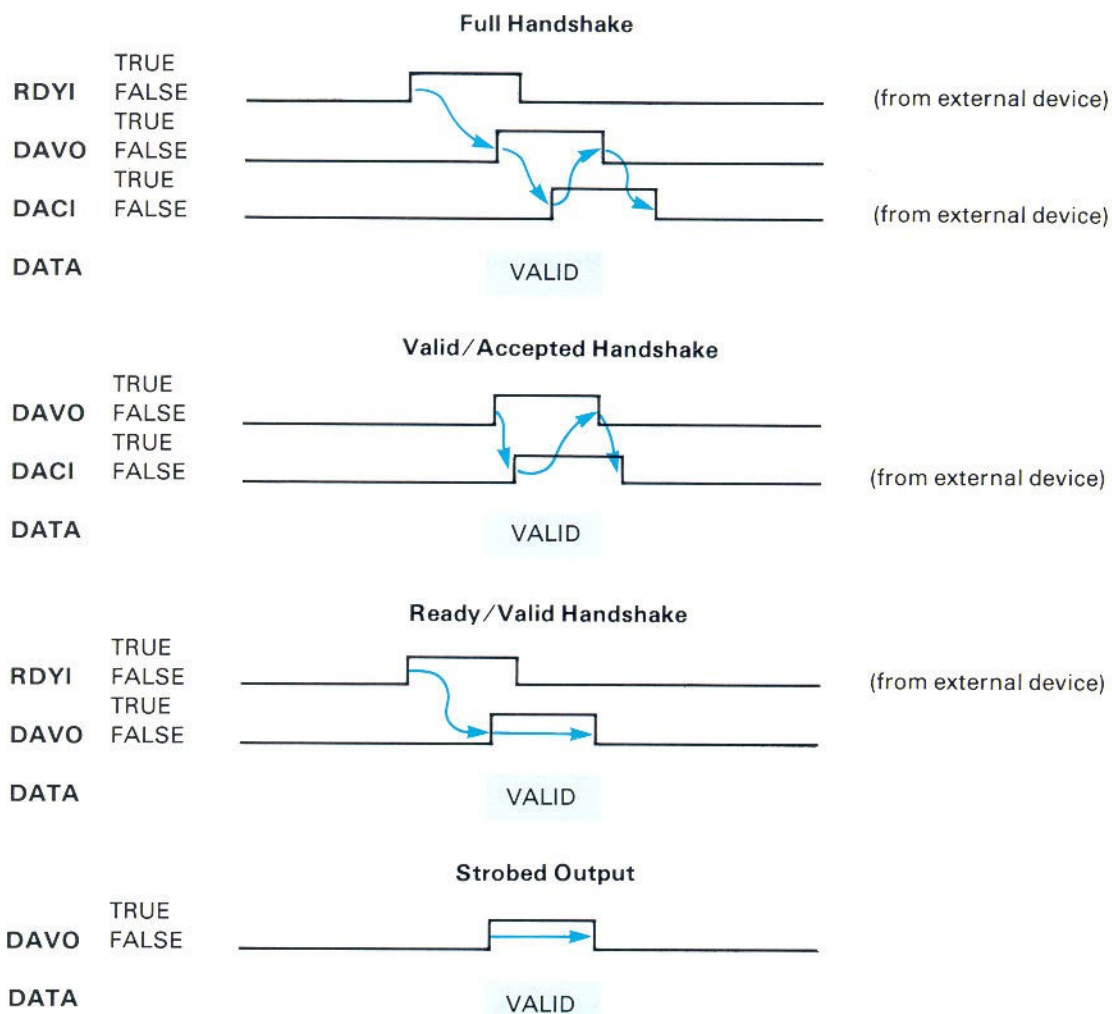
| Handshake | Selected by | Options |
|-------------------------------------|---------------|--|
| Full Handshake: RDYO, DAVI, DACO | (always used) | Positive Logic (R02-4 = 0) Negative Logic (R02-4 = 1) |

The diagrams below indicate how the three output handshake lines control the transfer of data. (The arrows show how changes in signal levels trigger subsequent changes.) For full and valid/accepted handshake, the DAVO signal may be limited to a time interval specified by control registers R02-3,0 and R03—the data will be removed from the data bus if DACI is not received within that interval. For ready/valid handshake and strobed output, the DAVO signal is true for the interval specified by R03 (and the 5-μs time unit).

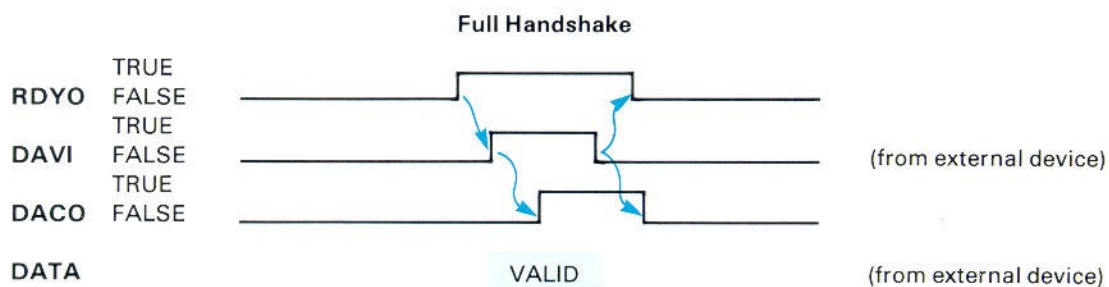
For HP-IL \leftrightarrow GPIO operations, the interface uses full handshake on GPIO. The external device should use the RDYO or DACO signal from the interface to determine that the interface is ready for the data or has accepted the data—otherwise, the external device doesn't know whether the interface is set to receive data. However, the external device is not required to use both of the signals.

Another handshake feature for HP-IL \rightarrow GPIO and HP-IL \leftarrow GPIO operations is provided by control register R01. R01-2 and R01-0 indicate the status of the DACI and RDYI input lines. If R01-7 equals 1, the HP-IL controller can set the DACO and RDYO output lines using R01-5 and R01-3.

HP-IL \rightarrow GPIO Operation



HP-IL \leftarrow GPIO Operation



Logic System. The interface uses positive logic or negative logic for the data buses and for the handshake lines—each specified independently by control register R02-5,4.

End-Of-Line Indicators. In its default condition, the interface is not set to detect characters or messages that indicate the end of a line of data (end-of-line indicators). Sequences of Data Bytes (and End Bytes) received from HP-IL are normally sent to the transfer buffer and then to the GPIO data bus without being altered. Similarly, sequences received from the GPIO bus are sent to HP-IL without being altered. Of course, the external device or an HP-IL device may respond to a certain character or sequence as an end-of-line indicator, even though the interface isn't set to recognize it. This condition is set up by R04-3 and R04-7 equal to 0.

The table below lists other options for indicating the end of a line of data. Using these options, the interface can detect an end-of-line indicator, delete the end-of-line characters, and insert a different end-of-line indicator at the end of the data. This feature allows you to operate an external device with HP-IL, even if the end-of-line indicators are different. These options are specified by R04-3 and R04-7. The end-of-line characters are specified by R04-6,2,1,0 and R05 through R14.

End-Of-Line Indicators

| Indicator Detected/Deleted | Indicator Added | Selected by |
|--|---|---|
| Output (HP-IL → GPIO) | | |
| None | None | R04-3 = 0 |
| End Byte, End Of Transmission, or Unlisten HP-IL message | R04-2,1,0 and R05 thru R12 on GPIO | R04-3 = 1 |
| Input (HP-IL ← GPIO) | | |
| None | None | R04-7 = 0 |
| Specified GPIO Sequence: R04-6, R13, R14 | End Byte on HP-IL | R04-7 = 1 |
| Specified GPIO Sequence: R04-6, R13, R14 | R04-2,1,0 and R05 thru R12 with End Byte on HP-IL | R04-7 = 1 R04-3 = 1 Device Dependent Talker 2 message* |
| * Selected for next line of data only. | | |

End of Data. For HP-IL ← GPIO operation (the interface is a talker), the interface receives data from the external device and sends it to HP-IL until it receives a Not Ready For Data message on HP-IL. It then terminates data transfer with an End Of Transmission message. This method of data termination is under the control of the HP-IL controller device—the external device doesn't terminate the transfer.

The transfer of data to HP-IL can also be terminated whenever the transfer buffer is empty. With this capability enabled, if the external device stops sending data to the buffer (or fails to keep up with the HP-IL data rate), the interface will send an End Of Transmission message. This additional method of terminating data transfer is enabled by setting control register R01-4 equal to 1. It allows the external device to terminate HP-IL ← GPIO data transfer.

For HP-IL ← GPIO operation, if the transfer buffer contains data for GPIO when the interface receives a Send Data message, the interface immediately sends an End Of Transmission message. This indicates that no data is available for HP-IL.

Specifications

The tables that follow describe the GPIO D-subminiature connector pin assignments, the temperature limits, electrical characteristics, and timing characteristics of the HP 82165A HP-IL/GPIO Interface. The electrical and timing characteristics describe conditions for the interface's GPIO interface.

GPIO Connector Pin Assignments



| | | | |
|----|--------------------------|----|------|
| 1 | RDYI | 14 | DAVO |
| 2 | DACI | 15 | RDYO |
| 3 | DAVI | 16 | DACO |
| 4 | $\overline{\text{GETO}}$ | 17 | DB0 |
| 5 | DA0 | 18 | DB1 |
| 6 | DA1 | 19 | DB2 |
| 7 | DA2 | 20 | DB3 |
| 8 | DA3 | 21 | GND |
| 9 | DB4 | 22 | DA4 |
| 10 | DB5 | 23 | DA5 |
| 11 | DB6 | 24 | DA6 |
| 12 | DB7 | 25 | DA7 |
| 13 | $\overline{\text{MSRQ}}$ | | |

Temperature Limits

| | |
|-----------|------------------------------|
| Operating | 0° to 65°C (32° to 149°F) |
| Storage | -40° to 75°C (-40° to 167°F) |

Electrical Characteristics

| Characteristic | Symbol | Minimum | Maximum | Unit | Condition |
|----------------------------|----------|---------|---------|---------------|--------------------------|
| Voltage to Any Pin | | | 5.5 | V | |
| Input Voltage, High Level | V_{IH} | 2.0 | | V | |
| Input Voltage, Low Level | V_{IL} | -0.3 | 0.8 | V | |
| Output Voltage, High Level | V_{OH} | 2.0 | | V | $I_{OH} = 15 \text{ mA}$ |
| Output Voltage, Low Level | V_{OL} | | 0.5 | V | $I_{OL} = 24 \text{ mA}$ |
| Input Current, High Level | I_{IH} | | 0.1 | mA | $V_{IN} = 5.5 \text{ V}$ |
| | | | 20 | μA | $V_{IN} = 2.7 \text{ V}$ |
| Input Current, Low Level | I_{IL} | | -0.2 | mA | $V_{IL} = 0.4 \text{ V}$ |
| Output Current, High Level | I_{OH} | | 15 | mA | |
| Output Current, Low Level | I_{OL} | -40 | -225 | mA | $V_{OL} = 0.0 \text{ V}$ |
| Output Rise Time | t_r | | 40 | ns | $R_L = 667 \Omega$ |
| Output Fall Time | t_f | | 40 | ns | $C_L = 45 \text{ pF}$ |

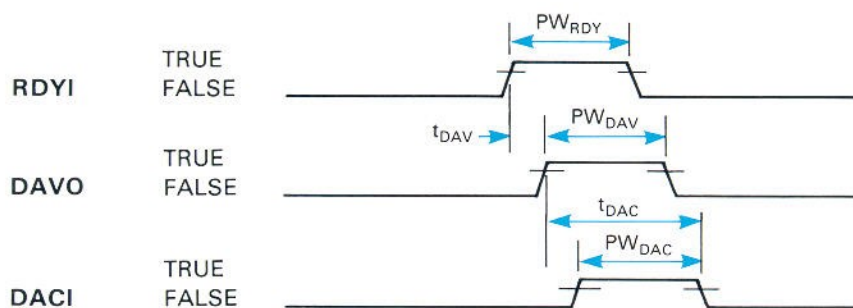
Timing Characteristics

| Characteristic | Symbol | Minimum | Maximum | Unit |
|--------------------------------------|----------------|---------|-----------------------|---------|
| Output (HP-IL → GPIO) Timing | | | | |
| RDYI Pulse Width | PW_{RDY} | 90 | | μs |
| DAVO Delay | t_{DAV} | | 350 | μs |
| DAVO Pulse Width | PW_{DAV} | | selectable (R02, R03) | |
| DAVO Pulse Width Tolerance | Δ_{DAV} | | ± 10 | μs |
| DACI Interval | t_{DAC} | 170 | | μs |
| DACI Pulse Width | PW_{DAC} | 74 | | μs |
| Input (HP-IL ← GPIO) Timing | | | | |
| RDYO Pulse Width | PW_{RDY} | 105* | | μs |
| DAVI Delay | t_{DAV} | | 60† | μs |
| DAVI Pulse Width | PW_{DAV} | 75/740† | | μs |
| DACO Delay | t_{DAC} | | 280 | μs |
| DACO Turnoff Delay | t_{OFF} | | 64* | μs |
| HP-IL Interfacing | | | | |
| HP-IL Data Rate | | | 1250 | bytes/s |
| \overline{MSRQ} Input Pulse Width | | 800 | | μs |
| \overline{GETO} Output Pulse Width | | 750 | 850 | μs |

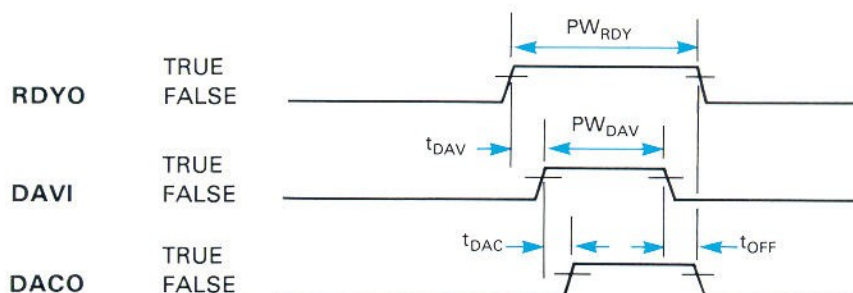
* Unless R01–7 equals 1.

† Use larger PW_{DAV} if DAVI isn't true within t_{DAV} .

Output (HP-IL → GPIO) Timing:



Input (HP-IL ← GPIO) Timing:



Care, Warranty, and Service Information

Care of the Interface

The HP 82165A HP-IL/GPIO Interface contains sensitive, electronic components that may be damaged by improper handling and use. Observe the following precautions to minimize the possibility of damage:

- When connecting wires or circuitry to the interface's GPIO interface, be sure the GPIO connector is disconnected from the interface. Plug in the connector *after* all of its external connections have been made.
- Take precautions against damage to the interface's circuitry from electrostatic discharge.
- Observe the electrical specifications listed on page 19.
- Observe the temperature limits listed on page 19.

Verifying Proper Operation

If at any time you suspect that your interface is not operating properly, you can verify its operation using the following test. (Some HP-IL controllers may be unable to send the device dependent messages needed for this test.) This test checks the continuity of the interface loop and the operation of most of the interface's circuitry.

1. Connect only the interface and HP-IL controller in the interface loop.
2. Using the controller, make the interface a listener and send it a Device Dependent Listener 1 message. This sets the interface to its Interface/HP-IL test condition.
3. Using the controller, send one or more Data Bytes to the interface.
 - If the HP-IL messages (including Data Bytes) are passed around the loop and back to the controller, the interface and HP-IL cables have proper continuity.
 - If HP-IL messages do not return to the controller, try this test again with the external device disconnected from the interface. This will tell whether the external device is interfering with HP-IL communication, possibly due to improper GPIO connections. If the external device isn't causing the problem, then the HP-IL continuity is bad. To determine the cause, try different cables or a different HP-IL peripheral. If HP-IL continuity is a problem for only the interface, then the interface requires service.
4. Using the controller, make the interface a talker and retrieve the previous Data Bytes from the interface. This ends the test.
 - If the retrieved Data Bytes match the original Data Bytes, the tested part of the interface is good. (Only the GPIO interface part of the interface is not tested by this test.)
 - If the retrieved Data Bytes don't match the original Data Bytes, the interface requires service.

Limited One-Year Warranty

What We Will Do

The HP 82165A HP-IL/GPIO Interface is warranted by Hewlett-Packard against defects in materials and workmanship for one year from the date of original purchase. If you sell your unit or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or, at our option, replace at no charge a unit that proves to be defective, provided you return the unit, shipping prepaid, to a Hewlett-Packard service center.

What Is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than an authorized Hewlett-Packard service center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE SPECIFIED DURATION OF THIS WRITTEN WARRANTY.** Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **IN NO EVENT SHALL HEWLETT-PACKARD COMPANY BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country.

Warranty for Consumer Transactions in the United Kingdom

This warranty shall not apply to consumer transactions and shall not affect the statutory rights of a consumer. In relation to such transactions, the rights and obligations of Seller and Buyer shall be determined by statute.

Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of manufacture. Hewlett-Packard shall have no obligation to modify or update products once sold.

Warranty Information

If you have any questions concerning this warranty, please contact an authorized Hewlett-Packard dealer or a Hewlett-Packard sales and service office. Should you be unable to contact them, please contact:

- In the United States:

Hewlett-Packard

Corvallis Division

1000 N.E. Circle Blvd.

Corvallis, OR 97330

Telephone: (503) 758-1010

Toll-Free Number: (800) 547-3400 (except in Oregon, Hawaii, and Alaska)

- In Europe:

Hewlett-Packard S.A.

7, rue du Bois-du-Lan
P.O. Box
CH-1217 Meyrin 2
Geneva
Switzerland
Telephone: (022) 83 81 11

Note: Do *not* send units to this address for repair.

- In other countries:

Hewlett-Packard Intercontinental

3495 Deer Creek Rd.
Palo Alto, California 94304
U.S.A.
Telephone: (415) 857-1501

Note: Do *not* send units to this address for repair.

Service

Hewlett-Packard maintains service centers in most major countries throughout the world. You may have your unit repaired at a Hewlett-Packard service center any time it needs service, whether the unit is under warranty or not. There is a charge for repairs after the one-year warranty period.

Hewlett-Packard products are normally repaired and reshipped within five (5) working days of receipt at any service center. This is an average time and could possibly vary depending upon the time of year and work load at the service center. The total time you are without your unit will depend largely on the shipping time.

Obtaining Repair Service in the United States

The Hewlett-Packard United States Service Center for the HP 82165A HP-IL/GPIO Interface is located in Corvallis, Oregon:

Hewlett-Packard Company

Corvallis Division Service Department
P.O. Box 999/1000 N.E. Circle Blvd.
Corvallis, Oregon 97330, U.S.A.
Telephone: (503) 757-2000

Obtaining Repair Service in Europe

Service centers are maintained at the following locations. For countries not listed, contact the dealer where you purchased your unit.

AUSTRIA
HEWLETT-PACKARD GmbH
Kleinrechner-Service
Wagramerstr.-Lieblgasse
A-1220 VIENNA
Telephone: (222) 23 65 11

BELGIUM
HEWLETT-PACKARD BELGIUM SA/NV
Boulevard de la Woluwe 100
Woluwelaan
B-1200 BRUSSELS
Telephone: (2) 762 32 00

DENMARK
HEWLETT-PACKARD A/S
Datavej 52
DK-3460 BIRKEROD (Copenhagen)
Telephone: (02) 81 66 40

EASTERN EUROPE

Refer to the address listed under Austria

FINLAND

HEWLETT-PACKARD OY
Revontulentie 7
SF-02100 ESPOO 10 (Helsinki)
Telephone: (90) 455 02 11

FRANCE

HEWLETT-PACKARD FRANCE
Division Informatique Personnelle
S.A.V. Calculateurs de Poche
F-91947 Les Ulis Cedex
Telephone: (6) 907 78 25

GERMANY

HEWLETT-PACKARD GmbH
Kleinrechner-Service
Vertriebszentrale
Berner Strasse 117
Postfach 560 140
D-6000 FRANKFURT 56
Telephone: (611) 50041

ITALY

HEWLETT-PACKARD ITALIANA S.P.A.
Casella postale 3645 (Milano)
Via G. Di Vittorio, 9
I-20063 CERNUSCO SUL NAVIGLIO (Milan)
Telephone: (2) 90 36 91

NETHERLANDS

HEWLETT-PACKARD NEDERLAND B.V.
Van Heuven Goedhartlaan 121
N-1181 KK AMSTELVEEN (Amsterdam)
P.O. Box 667
Telephone: (020) 472021

NORWAY

HEWLETT-PACKARD NORGE A/S
P.O. Box 34
Oesterndalen 18
N-1345 OESTERAAS (Oslo)
Telephone: (2) 17 11 80

SPAIN

HEWLETT-PACKARD ESPANOLA S.A.
Calle Jerez 3
E-MADRID 16
Telephone: (1) 458 2600

SWEDEN

HEWLETT-PACKARD SVERIGE AB
Enighetsvagen 3
Box 205 02
S 161 BROMMA 20 (Stockholm)
Telephone: (8) 730 05 50

SWITZERLAND

HEWLETT-PACKARD (SCHWEIZ) AG
Kleinrechner-Service
Allmend 2
CH-8967 WIDEN
Telephone: (057) 50111

UNITED KINGDOM

HEWLETT-PACKARD Ltd
King Street Lane
GB-WINNERSH, WOKINGHAM
Telephone: (734) 784774

International Service Information

Not all Hewlett-Packard service centers offer service for all models of HP products. However, if you bought your product from an authorized Hewlett-Packard dealer, you can be sure that service is available in the country where you bought it.

If you happen to be outside of the country where you bought your unit, you can contact the local Hewlett-Packard service center to see if service is available for it. If service is unavailable, please ship the unit to the address listed above under Obtaining Repair Service in the United States. A list of service centers for other countries can be obtained by writing to that address.

All shipping, reimportation arrangements, and customs costs are your responsibility.

Service Repair Charge

There is a standard repair charge for out-of-warranty repairs. The repair charges include all labor and materials. In the United States, the full charge is subject to the customer's local sales tax. In European countries, the full charge is subject to Value Added Tax (VAT) and similar taxes wherever applicable. All such taxes will appear as separate items on invoiced amounts.

Products damaged by accident or misuse are not covered by the fixed repair charges. In these situations, repair charges will be individually determined based on time and material.

Service Warranty

Any out-of-warranty repairs are warranted against defects in materials and workmanship for a period of one year from date of service.

Shipping Instructions

Should your unit require service, return it with the following items:

- A completed Service Card, including a description of the problem and system setup when the problem occurred.
- A sales receipt or other documentary proof of purchase date if the one-year warranty has not expired.

The product, the Service Card, a brief description of the problem and system configuration, and (if required) the proof of purchase date should be packaged in the original shipping case or other adequate protective packaging to prevent in-transit damage. Such damage is not covered by the original warranty; Hewlett-Packard suggests that you insure the shipment to the service center. The packaged unit should be shipped to the nearest Hewlett-Packard designated collection point or service center. Contact your dealer directly for assistance. (If you are not in the country where you originally purchased the unit, refer to International Service Information above.)

Whether the unit is under warranty or not, it is your responsibility to pay shipping charges for delivery to the Hewlett-Packard service center.

After warranty repairs are completed, the service center returns the unit with postage prepaid. On out-of-warranty repairs in the United States and some other countries, the unit is returned C.O.D. (covering shipping costs and the service charge).

Further Information

Service contracts are not available. Circuitry and designs are proprietary to Hewlett-Packard, and service manuals are not available to customers.

Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard service center.

Potential for Radio/Television Interference (for U.S.A. Only)

The HP 82165A HP-IL/GPIO Interface generates and uses radio frequency energy and, if not installed and used properly (that is, in strict accordance with the instructions in this manual), may cause interference to radio and television reception. It has been tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If the interface does cause interference to radio or television reception, which can be determined by turning the interface off and on, you are encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna.
- Relocate the interface with respect to the receiver.
- Move the interface away from the receiver.
- Plug the interface's power supply into a different outlet so that the power supply and the receiver are on different branch circuits.

If necessary, you should consult your sales representative or an experienced radio/television technician for additional suggestions. You may find the following booklet, prepared by the Federal Communications Commission, helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 004-000-00345-4.

Dealer and Product Information

For dealer locations, product information, and prices, please call (800) 547-3400. In Oregon, Alaska, and Hawaii, call (503) 758-1010.

Control Register Descriptions

The HP 82165A HP-IL/GPIO Interface contains 19 control registers. These registers control the way that the interface operates, as discussed throughout this manual. The tables shown below summarize the effects of the control registers.

When power is first supplied to the interface or when the RESET key is pressed, the control registers are initialized to the default values shown below. (The value for a register is determined by adding the indicated values of all bits that are "1".) The HP-IL controller can change the contents of the registers using the HP-IL Device Dependent Listener 0 message. (Refer to page 13.)

R00—Service Request Conditions (Default 01000000, Value=64)

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|------------------------|------------------------|-----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Status Service Request | Manual Service Request | All Status Service Requests | Buffer Busy | Buffer Full | No GPIO Handshake | Data Ready For HP-IL | Ready For HP-IL Data |
| 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable | 0=Disable 1=Enable |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R01—Control and Status of Handshake (Default 00000000, Value=0)

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|-----------------------|----------|-------------------|--------------------------|-------------------|-------------------|----------|-------------------|
| DACO and RDYO Control | Not Used | Set DACO | Buffer Empty End-of-Data | Set RDYO | DACI Status | Not Used | RDYI Status |
| 0=Disable 1=Enable | | 0=False 1=True | 0=Disable 1=Enable | 0=False 1=True | 0=False 1=True | | 0=False 1=True |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R02—Handshake and Data Formats (Default 11011000, Value=216)

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|---|----------|--|---|--|--|---|---|
| Handshake Options 00=Strobed 01=Ready/Valid 10=Valid/Accepted 11=Full | | Data Logic 0=Positive 1=Negative | Handshake Logic 0=Positive 1=Negative | DAVO Time Unit 0=100 μ s 1=5 μ s | Data Format 0=8-bit 1=16-bit | Data Bus Setup 0=Bidirectional 1=Unidirectional | DAVO Timeout 0=Disable 1=Enable |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R03—DAVO Pulse Width (Default 00000101, Value=5)

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|---|----------|----------|----------|---------|---------|---------|---------|
| Total value specifies number of DAVO time units added to basic 25- μ s DAVO pulse width, except that a value of zero specifies 256 units. (DAVO pulse width is limited to 25 μ s plus specified number of time units—40 μ s minimum.) | | | | | | | |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R04—Character Sequences (Default 00000000, Value=0)

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|---|--|----------|----------|--|---|---------|---------|
| Detect/Delete End-Of-Line Characters 0=Disable 1=Enable | End-Of-Line Detect/Delete Number 0=2 Characters 1=1 Characters | Not Used | Not Used | Insert End-Of- Line Characters 0=Disable 1=Enable | End-Of-Line Insert Number 000=1 Character 001=2 Characters : : 111=8 Characters | | |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R05—Eighth From Last End-Of-Line Insert Character (No Default)**R06—Seventh From Last End-Of-Line Insert Character (No Default)****R07—Sixth From Last End-Of-Line Insert Character (No Default)****R08—Fifth From Last End-Of-Line Insert Character (No Default)****R09—Fourth From Last End-Of-Line Insert Character (No Default)****R10—Third From Last End-Of-Line Insert Character (No Default)****R11—Second From Last End-Of-Line Insert Character (No Default)****R12—Last End-Of-Line Insert Character (No Default)****R13—First End-Of-Line Detect/Delete Character (No Default)****R14—Second End-Of-Line Detect/Delete Character (No Default)**

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|--|----------|----------|----------|---------|---------|---------|---------|
| Total value specifies 8-bit code of character. | | | | | | | |
| Value=128 | Value=64 | Value=32 | Value=16 | Value=8 | Value=4 | Value=2 | Value=1 |

R15, R16, R17, R18—Reserved for Future Use

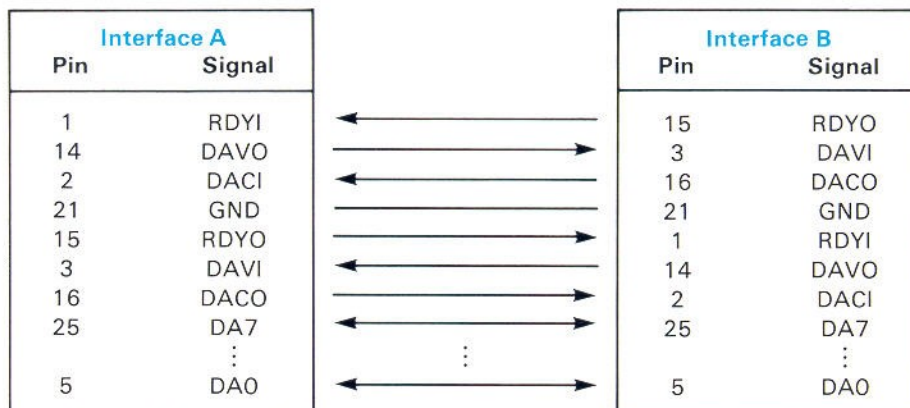
Typical Installations

This appendix illustrates several electrical installations using the HP 82165A HP-IL/GPIO Interface. These examples illustrate the types of GPIO interfacing that may be used.

Note: The interface's data lines do not have consecutive pin numbers. The diagrams below don't give the pin number for each data line—refer to page 19 or to the interface's label for pin numbers.

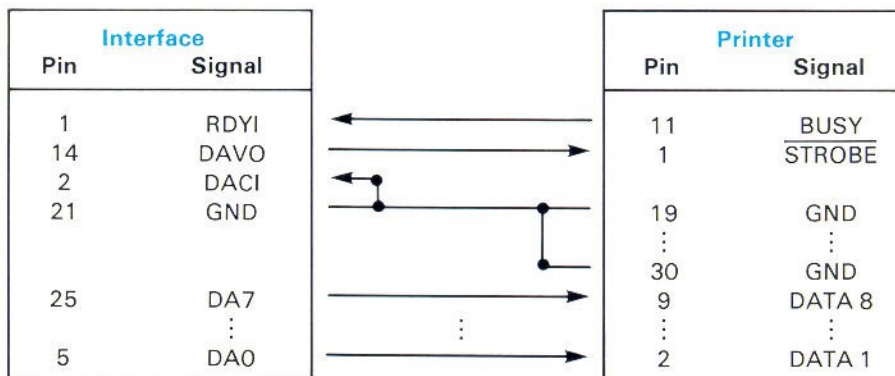
Interface to Interface

Two interfaces may be connected together at their GPIO interfaces. This provides the capability for one HP-IL system to communicate with another HP-IL system. Each HP-IL controller must set up its interface—one for HP-IL → GPIO operation and one for HP-IL ← GPIO operation. The control registers are set to their default conditions.



Interface to Parallel Printer

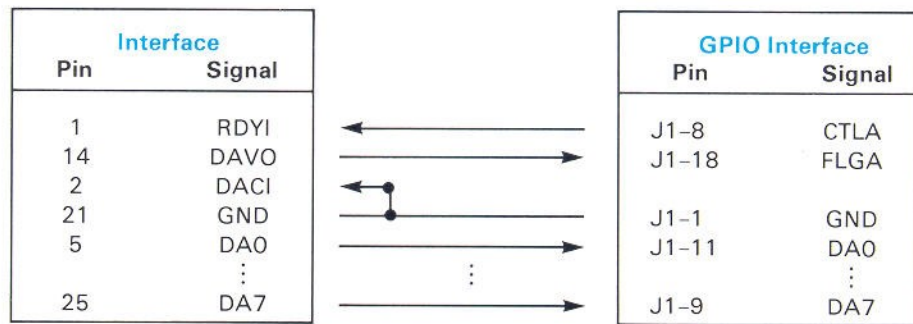
The interface may be connected to a printer that uses a standard printer interface, often called the "parallel printer" or "Centronics-type" interface. Using this installation, the HP-IL controller can print information on a standard printer. The control registers are set to their default conditions. Note that DACI is connected to ground, making this signal always true.



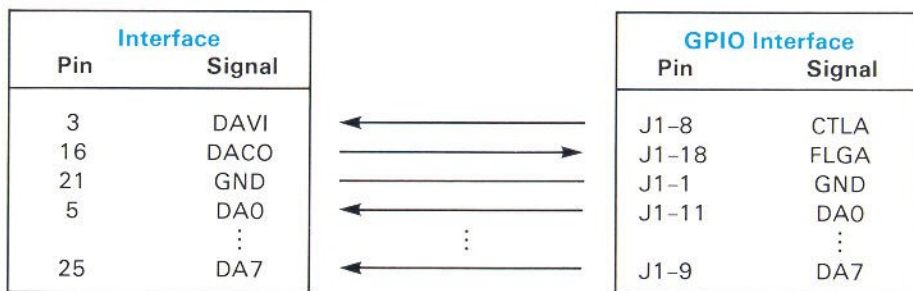
Interface to HP 82940A GPIO Interface

The interface may be connected to a Series 80 GPIO interface using any of the five installations described below. These installations allow a Series 80 computer to interact with HP-IL. For each installation, the computer must use the device address that corresponds to the port configuration.

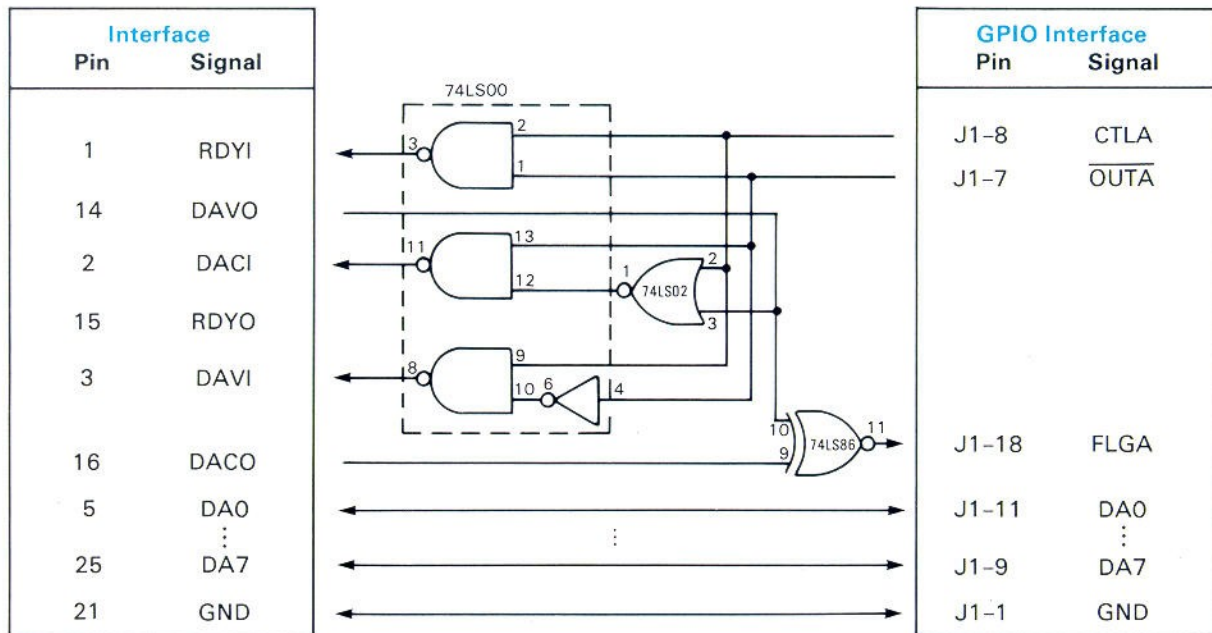
The first installation provides one-way communication from the interface to the GPIO interface. The interface's control registers use their default values. (The GPIO interface must have bit 5 of register 4 equal to 1—Busy to Ready; other registers use their default values.)



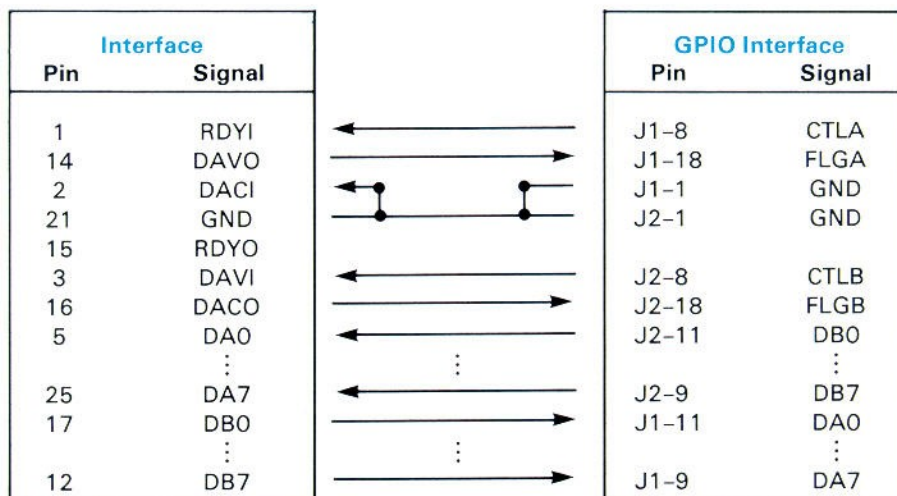
The second installation provides one-way communication from the GPIO interface to the interface. The interface uses the default values for its control registers. (The GPIO interface must have bits 4 and 0 of register 3 equal to 1—FLGA and CTLA negative-true—and bit 0 of register 8 equal to 1—Output Enable A; other registers use their default values.)



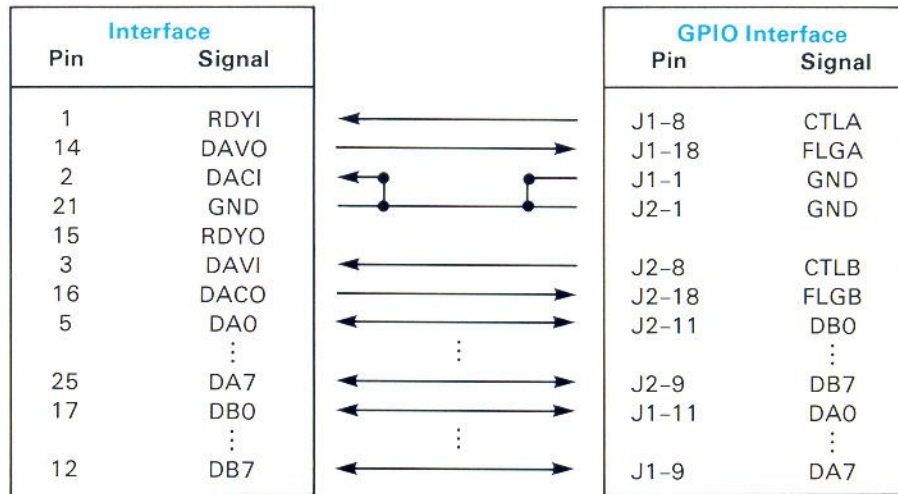
The next installation uses an 8-bit bidirectional data bus. The extra circuitry eliminates the need to modify the interface's control registers—the default values can be used. (The GPIO interface must have bit 0 of register 8 equal to 1—Output Enable A; other registers use their default values.)



This installation uses an 8-bit unidirectional data bus. It doesn't require any extra circuitry, although the interface's control registers must be modified. Control register R02 must be set to 11001010 (value 202)—full handshake, positive data and handshake logic, 5- μ s time unit, 8-bit unidirectional data, disabled timeout; other control registers may be set to their default values. (The GPIO interface must have bit 1 of register 8 equal to 1—Output Enable B; other registers use their default values.)



The last installation uses a 16-bit bidirectional data bus. Control register R02 must be set to 11001100 (value 204)—full handshake, positive data and handshake logic, 5- μ s time unit, 16-bit bidirectional data, disabled timeout; other control registers may be set to their default values. (The GPIO interface must have bits 1 and 0 of register 8 equal to 1—Output Enable B and Output Enable A; other registers use their default values.)



Using the HP-41 As a Controller

The HP-41 calculator, when used with an HP 82160A HP-IL Module, can control the interface and its external device. The following interface control functions are useful for sending instructions and sending and receiving information.

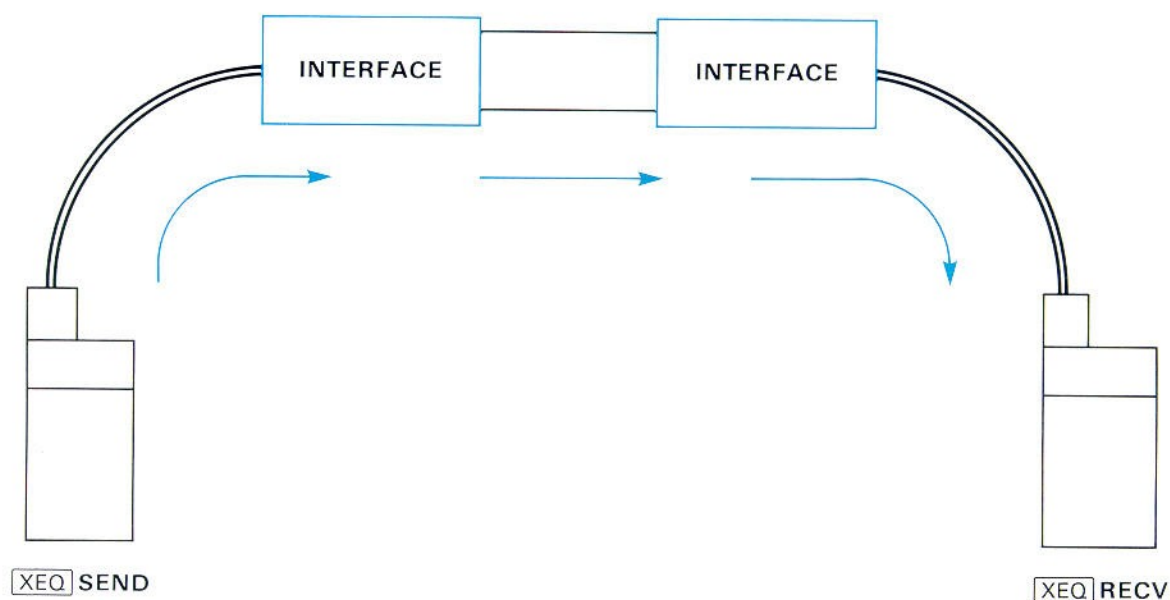
| Function | Response |
|--|---|
| Calculator → Interface | |
| OUTA * | Sends the character codes of the characters in the ALPHA register to the interface and external device, followed by an end-of-line indicator (unless suppressed by flag 17 set). |
| ACA † | Sends the character codes of the characters in the ALPHA register to the interface and external device. No end-of-line indicator is sent. |
| PRA † | Sends the character codes of the characters in the ALPHA register to the interface and external device, followed by an end-of-line indicator. |
| ACX † | Sends the character codes of the digits in the X-register (using the current display format) to the interface and external device. No end-of-line indicator is sent. |
| PRX † | Sends the character codes of the digits in the X-register (using the current display format) to the interface and external device, followed by an end-of-line indicator. |
| ACCHR † | Sends the character code specified in the X-register to the interface and external device. This enables you to send characters that aren't among the standard HP-41 character set, such as Escape (code 27) and Bell (code 7). No end-of-line indicator is sent. (Characters 10, 13, and 126 can't be sent with this function.) |
| ADV † | Sends an end-of-line indicator to the interface and external device. |
| PRBUF † | Sends an end-of-line indicator to the interface and external device. |
| TRIGGER * | Makes the interface signal the external device on the $\overline{\text{GETO}}$ line. |
| Calculator ← Interface | |
| INA ‡ | Fetches the character codes of up to 24 characters from the interface's transfer buffer. The characters are stored in the ALPHA register. |
| IND ‡ | Fetches the character codes of a sequence of digits from the interface's transfer buffer. The characters are interpreted as a number, which is placed in the X-register. |
| INSTAT ‡ | Fetches one number (byte) representing the interface's current status and allows the status register to be updated. Flags 00 through 07 are set according to the eight status bit values, and the status number (modulo 64) is placed in the X-register. |
| FINDID | If the ALPHA register contains HP82165 , the address of the interface is placed in the X-register. |
| <p>* The interface must either be the primary device selected by the HP-41 or—under certain conditions—be a listener (using [LISTEN]).</p> <p>† The interface must be the primary device selected by the HP-41 and the calculator must be in Manual mode (using [MANIO]).</p> <p>‡ The interface must be the primary device selected by the HP-41.</p> | |

The end-of-line indicator for the HP-41 is Carriage Return (CR), Linefeed (LF)—character codes 13 and 10. Flag 17 controls how the HP-41 uses end-of-line indicators. If flag 17 is clear, the HP-41 includes CR LF at the end of each sequence of Data Bytes it sends (as from `OUTA`) and interprets CR LF as an end-of-line indicator in data it receives. If flag 17 is set, the HP-41 doesn't send CR LF at the end of Data Byte sequences and ignores CR LF in sequences it receives. However, note that several functions *always* include an end-of-line indicator, regardless of the status of flag 17.

In addition to the functions listed above, any of the general printer functions in the HP-IL module may be used to send information to the interface and external device. Each line of information as formatted by a printer function is always followed by an end-of-line indicator. To use these functions, ensure that the interface is the primary device selected by the HP-41 and that the calculator is in Manual mode.

Note that the HP 82160A HP-IL Module doesn't give the HP-41 the capability of sending device dependent messages. For this reason, *the calculator and HP-IL module can't store or read data in the interface's control registers*—you must use the interface with the default values in its control registers. (Also, the calculator and HP-IL module can't perform the Interface/HP-IL test described in appendix A.)

Application: Passing Information Between Systems. In this application, two HP-IL systems are connected by interfaces. Each loop is controlled by one HP-41. One loop is set up for the HP-41 to send data to an interface. The other loop is set up for the HP-41 to receive data from an interface. (Connect the interfaces as shown in appendix C.)



The following program is stored in each calculator. Execute "RECV" on the calculator that is to receive ALPHA data, and execute "SEND" on the calculator that is to send ALPHA data. Then enter a message at the sender followed by `R/S`.

| | |
|-----------------|---|
| 01♦LBL "RECV" | Program to receive ALPHA data. |
| 02 XEQ "SELINT" | Selects interface as primary device. |
| 03♦LBL 01 | |
| 04 INSTAT | Fetches current interface status. |
| 05 FC? 01 | Tests bit 1 of status (Data Ready For HP-IL). |
| 06 GTO 01 | Branch for "0" in bit 1. |
| 07 INA | Fetches ALPHA data. |
| 08 AVIEW | Displays ALPHA register. |
| 09 GTO 01 | Branches to status loop. |
| 10♦LBL "SEND" | Program to send ALPHA data. |
| 11 XEQ "SELINT" | Selects interface as primary device. |
| 12♦LBL 02 | |
| 13 "MESSAGE?" | Enters prompt message. |
| 14 AON | Activates ALPHA mode. |
| 15 PROMPT | Prompts for ALPHA input. |
| 16 AOFF | |
| 17 OUTA | Sends ALPHA data. |
| 18 GTO 02 | |
| 19♦LBL "SELINT" | Subroutine to select interface as primary device. |
| 20 "HP82165" | Specifies interface's identity. |
| 21 FINDID | Places interface's address in X-register. |
| 22 X=0? | |
| 23 STOP | Stops execution if interface isn't in loop. |
| 24 SELECT | Selects interface as primary device. |
| 25 CF 17 | Specifies use of end-of-line indicators. |
| 26 RTN | |

Application: Controlling a Printer. In this application, an HP-41 controls a interface connected to a parallel printer—in this example, a Centronics 737-1 printer. (The printer is connected to the interface as described in the second example in appendix C.) This printer responds to special instructions encoded as "control codes"—sequences of character codes—listed below. (Other printers may have different coding or different capabilities.)

| Character Code Sequence | Instruction |
|-------------------------|---|
| 14 | Terminates underlined printing. |
| 15 | Selects underlined printing. |
| 27, 14 | Selects elongated printing for one line only. |
| 27, 17 | Selects secondary (proportional) character set. |
| 27, 19 | Selects primary character set. |

The following program for the HP-41 enables you to print using elongated secondary characters or normal primary characters, either underlined or not underlined. Set flag 01 for underlined printing, or clear flag 01 for printing without underlining. Place the desired characters in the ALPHA register, then execute "PNORM" for normal primary characters or "SLONG" for elongated secondary characters. (The program assumes that the interface is the primary device and that the calculator is in Manual mode.)

| | | |
|----------------|---|--|
| 01♦LBL "PNORM" | } | Selects primary character set. |
| 02 27 | | |
| 03 ACCHR | | |
| 04 CLX | | |
| 05 19 | | |
| 06 ACCHR | } | Selects secondary character set. |
| 07 GTO 05 | | |
| 08♦LBL "SLONG" | | |
| 09 27 | | |
| 10 ACCHR | | |
| 11 CLX | } | Selects elongated printing. |
| 12 17 | | |
| 13 ACCHR | | |
| 14 CLX | | |
| 15 27 | | |
| 16 ACCHR | } | Selects underlined printing if flag 01 set. |
| 17 CLX | | |
| 18 14 | | |
| 19 ACCHR | | |
| 20♦LBL 05 | | |
| 21 CLX | } | Sends contents of ALPHA register. |
| 22 15 | | |
| 23 FS? 01 | | |
| 24 ACCHR | | |
| 25 ACA | | |
| 26 CLX | } | Terminates underlined printing, if used. Sends CR LF (and prints line). |
| 27 14 | | |
| 28 ACCHR | | |
| 31 PRBUF | | |
| 32 CLX | | |
| 33 + | } | Restores X-register. |
| 34 RTN | | |



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